New Airborne Remote Sensing Service Enhances Pipeline Integrity Assessment



by (L to R) **Daniel Brake, Michael Clayton** and **Steven Stearns, Eastman Kodak Company, Active Imaging Services,** Rochester, NY

Kodak is finishing development of a new Airborne Natural Gas Emission Lidar (ANGEL) pipeline survey service. The service employs advanced optical remote sensing technology to inspect natural gas transmission pipelines. From a quarter-mile in the air, it will remotely detect, quantify and report the precise locations of natural gas leaks.

The ANGEL Service is being developed under a cooperative development agreement with the DOE National Energy Technology Laboratory and supports the directives of the Pipeline Safety Improvement Act of 2002 (HR3609). This cooperative development agreement will culminate in a field demonstration scheduled for September. Figure 1 shows a conceptual view of an airborne survey operation.

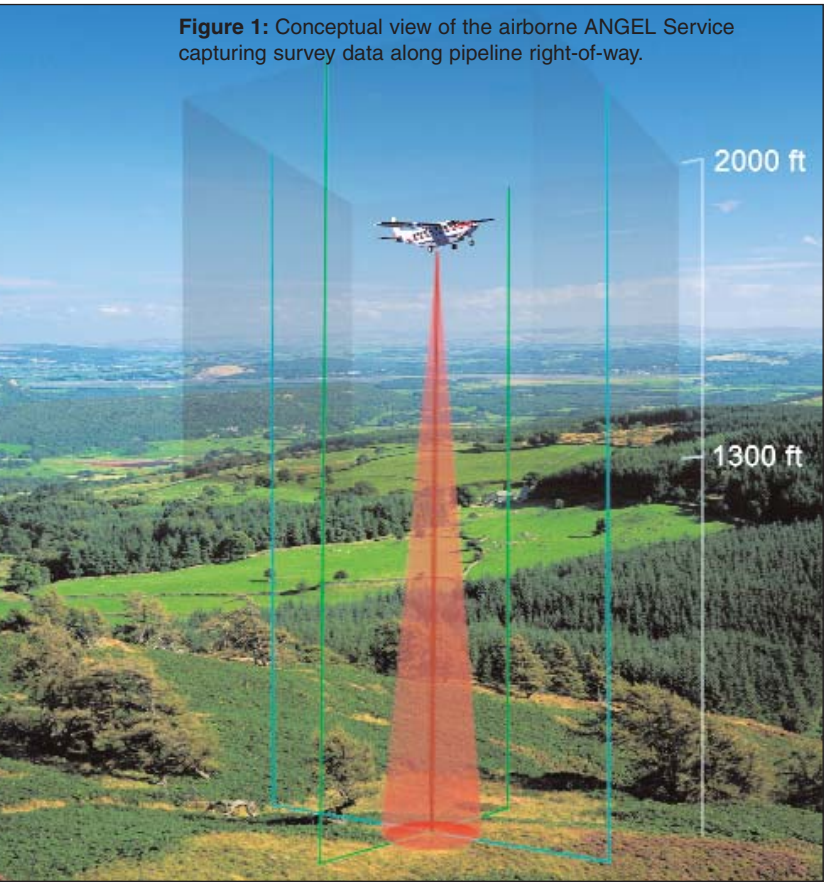

Figure 1: Conceptual view of the airborne ANGEL Service capturing survey data along pipeline right-of-way.

Boosting Survey Value

Kodak expects the ANGEL Service to improve integrity assessment for pipeline operators in a variety of ways. It adds a measurable degree of confidence to integrity verification by outperforming conventional detection methods in terms of sensitivity, accuracy, efficiency, and coverage. For bubble-tight gas transmission pipelines, operators can apply the comprehensive data collection to provide real-time failure detection in the intervals between expensive integrity verifications such as in-line inspections (ILI) and full-pressure testing. The service also complements direct assessment (DA) and unpiggable pipeline inspection methodologies by precisely identifying integrity failure points.

For less tight pipelines, ANGEL delivers a data set upon which a comprehensive integrity management effort can be based. Integrity managers can apply the data to prioritize repair and maintenance activities by distinguishing between potentially dangerous scenarios, low priority leaks, and nuisance emissions. A new data layer can also be used to improve confidence levels in statistical leak forecasting models.

ANGEL will be offered as an outsourced service similar to ILI. This will alleviate the need for operators to make capital purchases, maintain and calibrate sophisticated remote sensing equipment, hire and qualify additional personnel, or manage complex field logistics.

Regulations, safety, and cost concerns have set the stage for remote sensing. The existing U.S. natural gas transmission infrastructure consists of more than 300,000 miles of buried pipeline. DOE estimates that natural gas consumption will increase by more than 50% (to 34 Tcf) by 2020, placing additional demands on the nation's aging natural gas infrastructure. This combination of aging pipeline materials and increased demand presents an environment where natural gas emissions may occur with greater frequency and volumes. The identification and reduction of natural gas transmission pipeline emissions is important for public and environmental safety, natural gas conservation, greenhouse gas emissions, and overall natural gas cost control.

To address this situation, the federal government instituted additional pipeline safety and security requirements in the form of HR3609. This law places greater emphasis on the research, development, demonstration, and standardization of new leak detection and rupture prevention equipment and methodologies. The DOT, DOE, and NIST responded by sponsoring cooperative development initiatives such as one that fueled the creation of ANGEL. In addition, the EPA is actively involved with its Natural Gas STAR program aimed at assisting the pipeline industry in reducing fugitive emissions, improving efficiency, and increasing profitability.

For operators to comply with U.S. DOT/RSPA regulations (49CFR192.706), they must conduct leakage surveys of a transmission line at intervals not exceeding 15 months, but at least once each calendar year, with the use of leak detection equipment. High consequence areas (HCA) require more frequent inspections, up to four times per year. Conventional leak surveys typically rely on inspection crews walking or driving slowly along the right of way while using flame ionization

detectors (FID) that "sniff" the presence of hydrocarbons.

This technique is slow, expensive, and produces false positives due to its inability to differentiate natural gas from other hydrocarbon producing sources. Recently developed truck-bumper-mounted optical systems that detect methane appear to be an improvement, but are still limited due to low ground speed, narrow coverage area, fragility, and their inability to navigate difficult terrain and ground cover.

Concept Validation

Kodak, which has pioneered remote sensing for more than 50 years, recognized gas detection as a promising application for its technology. The Kodak development team validated its concept by meeting with natural gas transmission pipeline operators representing more than 50% of the total U.S. interstate pipeline mileage. Research heads, integrity managers, and operations personnel were briefed about Kodak's airborne leak detection technology approach. The industry indicated that the proposed ANGEL Service would be an improvement in terms of sensitivity, accuracy, efficiency and coverage over current pipeline leak detection methods and would lead to increased levels of integrity confidence.

Beta testing of the sensor platform will begin with flight tests over operating natural gas pipelines in cooperation with major pipeline owners this summer. In September, it will participate in the DOE/NETL Field Demonstration of natural gas remote sensing systems. Test results will be published by DOE/NETL at the conclusion of the demonstration. The service is scheduled for commercial availability starting in the fourth quarter.

Technology

The ANGEL Ser-vice uses a DIAL (Differential Ab-sorption Lidar) sensor system mounted in an aircraft. A DIAL sensor was chosen because it can deliver superior sensitivity, which translates into accurate detection of very small leaks with very low frequency of false positives. The system's tuned lasers can accurately de-tect, quantify, and discriminate both methane and ethane gases. The emitter/detector design of the system allows it to operate in a broad range of environmental conditions including day or night, sun and shadow, overcast, haze, and smog. It performs well over a wide variety of surface conditions, including dense vegetation, bare soil, sand, gravel, asphalt, concrete, and snow.

In addition to the emitter/detector, the sensor system incorporates active pointing and scanning subsystems. The pointing subsystem tracks the lasers to the pipeline right-of-way (ROW) according to preloaded pipeline geospatial data. This enables the system to precisely track the pipeline without any human intervention, automatically compensating for aircraft movement. The scanning subsystem paints the ROW with a series of laser pulses, acquiring up to 6,000 individual surface measurements per second.

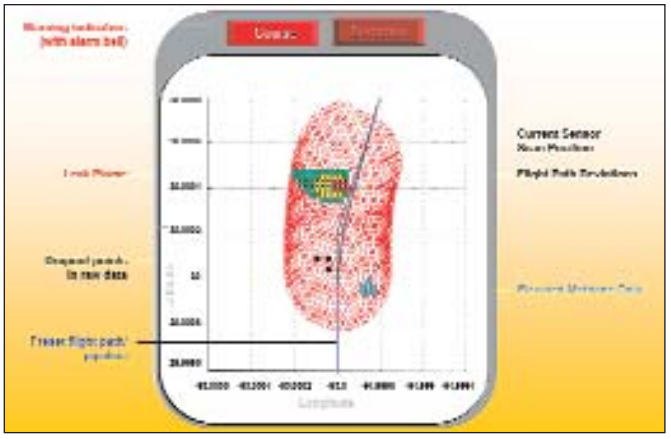

Figure 2: Notional real-time display in the aircraft. Display dots are color coded to reflect the measured concentration wave length values for methane and ethane.

Mounted in a fixed-wing aircraft, the DIAL sensor maintains its rated sensitivity while operating at an altitude of approximately 1,500 feet and at airspeeds of 150 mph. This configuration enables the service to collect up to 1,000 miles of ROW data per day. As the sensor system is flown along the pipeline ROW, an onboard real-time display system (Figure 2) presents the size, shape, concentration, and location of any gas plumes detected.

Alarms alert the crew to the presence of predetermined thresholds of natural gas emissions in real time for immediate operator notification. Minor gas emissions are identified and fully characterized during more detailed ground processing at the conclusion of the flight. ***P&GJ***

ACKNOWLEDGMENT:
Based on a presentation at the GTI Natural Gas Technology II Conference in Phoenix on Feb. 10, 2004.

Editor's Note: *The Kodak division that is developing the ANGEL Service is in the process of being purchased by ITT Industries. Closing on the transaction is expected this summer.* ***Authors: Daniel E. Brake*** *is Director, Active Imaging Services, Eastman Kodak. Previously he was worldwide General Manager of Kodak's Aerial Imaging business unit. He holds a B.S. degree in Imaging Science from the Rochester Institute of Technology.*

Michael J. Clayton *is Chief Technology Officer, System Integration Manager, Eastman Kodak, with more than 35 years experience in remote sensing. Previously he was Director of Technical Operations, responsible for all product and service development and delivery. He received a B.S.M.E. degree from the University of Notre Dame and an M.S. degree in Management of Technology from National Technological University. He attended the Advanced Management College at Stanford University.*

Steven V. Stearns, Ph.D., *is Project Manager, Principal Investigator, Eastman Kodak. He is the Chief Scientist for the Airborne Natural Gas Leak Detection System project. He has been the project leader in a number of successful hyperspectral exploitation contracts with the Air Force Research Labs and has more than eight years of experience in hyperspectral and Lidar data exploitation. He holds M.S. and Ph.D. degrees in Geology from Texas A&M University and a B.A. degree in Geology from Colby College, Waterville, ME.*